Water Treatment NOTES

Cornell Cooperative extension, of Human Ecology

Methyl Tertiary Butyl Ether (MTBE) and Drinking Water

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Methyl tertiary Butyl ether (MtBE) is a chemical that is currently added to gasoline for cleaner combustion. Initially (1979) it was used in low concentrations (about 2-3%) to raise the octane of gasoline, replacing lead which was previously used as an octane enhancer. In 1990, amendments to the Clean Air Act were enacted which stated that in certain parts of the US, either year round or only in winter, an oxygenate had to be added to gasoline. The benefit of oxygenate reformulated gasoline is that it promotes more complete combustion and reduces emissions of carbon monoxide, ozone, and air pollutants such as benzene.

Currently MtBE is used mainly as an oxygenate rather than as an octane enhancer and its concentration in gasoline is substantially higher (generally from 11-15%) [1].

By the mid 1990s concerns arose about MtBE contamination of drinking water. As a component of gasoline it is thought to get into the environment through spills. Such spills may be large, like those from a leaking underground or above-ground gasoline storage tank. Spills may also be small, such as those which can occur while refueling, discarding old gasoline improperly, or leaking gasoline from vehicles

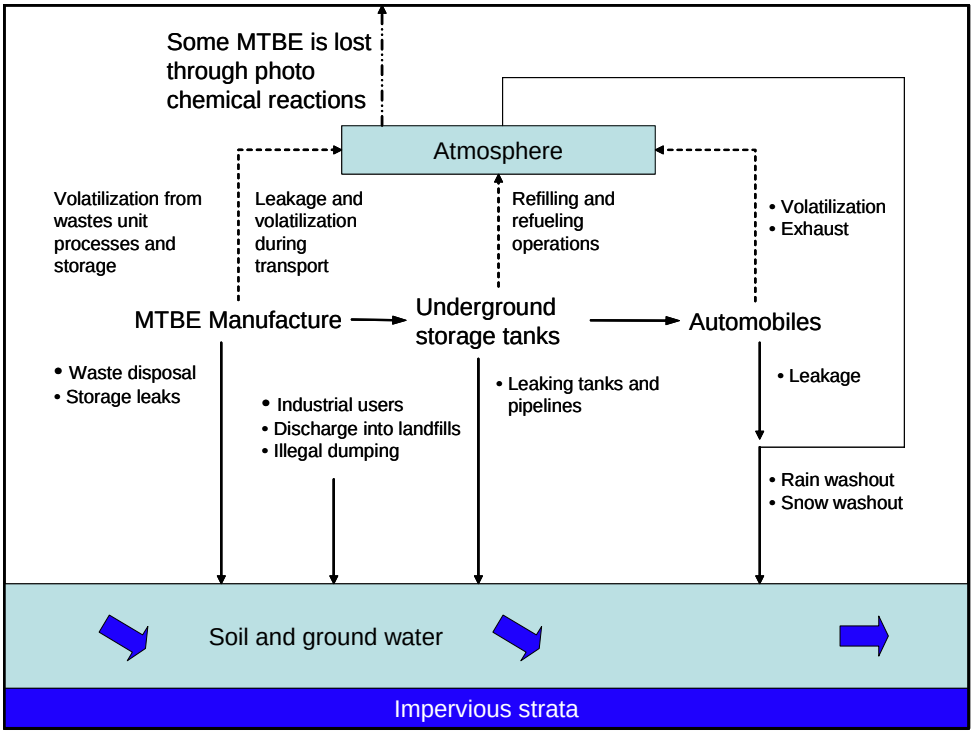

Figure 1: Sources of pathways for MTBE contamination in groundwater [2]

When gasoline is spilled, the MtBE can evaporate very quickly, but when it comes into contact with water it dissolves. The contamination of water by MtBE is shown in Figure 1. Because MtBE does not bind well to soil and is most likely not stored by plants, it is very persistent in groundwater. Large plumes of MtBE are found in aquifers and are hard to clean up.

MtBE has now been found in a great number of wells in over 20 states, including New York State [3, 4]. During testing in 1998, New York State had the highest number of contaminated domestic wells, which were largely due to leaking underground storage tanks [5].

The biggest drawback for MtBE is that it has a pungent turpentine-like smell that can affect the taste of water negatively in low concentrations. Thus, well water in the vicinity of these spills can be easily affected [2, 6].

In 1997, the USEPA (United States Environmental Protection Agency) set a non-statutory drinking-water advisory for MtBE in drinking-water of 20–40 µg/liter due to the odor and taste. It was based on four different research publications which showed a threshold range between 15-180 µg/liter for odor and 24-135 µg/liter for taste.

Health Risks

The potential effects of MtBE on human health depend on how much MtBE is present in the water and the length and frequency of exposure. No studies have yet been completed to determine if MtBE causes cancer in humans; however, tests on rats have shown that MtBE can cause cancer in animals [7-10]. Although in general, carcinogens for animals are accepted as carcinogens for humans, this was not the case for MtBE due to its several toxicology [11], but there was an agreement on the term "possibly carcinogenic to humans". There is also a high probability that if MtBE were carcinogenic, the maximum contaminant level allowed in drinking water would be higher than the drinking water advisory of 20 µg/liter. Other effects of exposure to (or ingestion/inhalation of) MtBE include the following: headaches, eye irritation, nose and throat irritation, cough, nausea, dizziness and disorientation. [12]. Also there is a tentative link between MTBE and asthma in children, but this claim has not yet been substantiated by research [13].

Other oxygenates

The positive side of MtBE addition to gasoline is that it does help to keep the air more free of ozone and carbon monoxide. That was the reason it was added to gas in such high amounts in the first place. The Clean Air Act Amendments of 1990 (CAA) require the use of oxygenated gasoline in areas with unhealthy levels of air pollution.

The CAA does not specifically require MTBE. Refiners may choose to use other oxygenates such as ethanol [1], ethyl tert-butyl ether (ETBE), tert-amyl methyl ether (TAME), and diisopropyl ether (DIPE).

Because MtBE was the easiest and cheapest to produce (it is a waste product from refineries) it became the standard. Now that the MtBE-ban is in a number of states and the CAA is still valid, most producers will turn to ethanol as the added oxygenate.

Policy process

A maximum drinking water contaminant level for MtBE set by the EPA will be issued no earlier than 2010 [14]. MtBE is on the USEPA's candidate contaminant list, but due to a great amount of testing, health effect research, and rule development it takes a very long time before it becomes part of the drinking water standards.

Statewide bans for MtBE in gasoline are more likely to occur soon. Currently there is legislation in effect for an MtBE ban in 19 states [15]. In most states the ban is only for MtBE, but in some states (MN, NH) it is also for other oxygenates. The federal legislation is a slow process, and at the moment a federal ban will not be issued anytime soon. A controversial topic is the liability waiver for manufacturers that is in the current draft of an energy policy bill that will go to the Senate soon. This waiver would allow companies that produce MTBE to not have to pay for the clean up. The AWWA (American Waterworks Association) is trying to stop this provision in the energy bill, citing it as unfair for communities to bear the burden of cleanup alone.

Water treatment solutions

MtBE is highly soluble in water and is quite hard to remove after contamination. Activated carbon (GAC), the most used removal agent for VOCs (Volatile Organic Compounds), is not working very well, except when using carbon that is optimized for trace removal [16]. A great number of other techniques have been researched, but most are accompanied by high cost or low removal rates. One of the more promising techniques is peroxides together with ozone [17]; this is however only feasible for larger amounts of water and has the side effect of bromate formation. In the following table, treatment techniques and their use for MtBE removal are summarized

Table 1: Comparative evaluation* of technologies for MtBE removal [2]

Considerations	Air-stripping	GAC Adsorption	Advanced Oxidation	Biofiltration
Effectiveness	Moderate; dependent on air-to-water ratio	Poor to moderate; limited adsorption capacity for MtBE	Ultraviolet-peroxide can be effective; ozonation alone is less effective than ozone-peroxide oxidation	Resistant to biodegradation, often not very effective; more efficient if used with oxidation
Treatment cost	Moderate; relatively high operating cost because high air-to-water ratio is required; treating off-gas greatly increases cost	Greater than air-stripping; relatively high operating cost because of need for frequent GAC replacement	For MtBE, depends on oxidation method; can be less expensive than GAC or air-stripping with off-gas control. For other organic compounds, typically more expensive than GAC or air-	Moderate; probably used in conjunction with advanced oxidation processes
Advantages	Removes other VOCs (volatile organic compounds)	Removes other organic compounds; can treat other taste and odor problems; pretreatment with air-stripping can increase GAC life.	Oxidizes other organic compounds; can treat other taste and odor problems	Removes other biogrowth-promoting compounds
Disadvantages	May require GAC or incineration as secondary containment to meet air emission requirements	GAC regeneration or disposal required	By-products formed; potential biogrowth problem; potential bromate formation	Slow; requires continuous monitoring
Operational problems	Scaling and freezing during cold seasons	Requires breakthrough monitoring	Requires optimal use of oxidants	Requires removal of disinfectants and oxidants

*This table is for general relative comparison purposes only. Additional information would be required to provide a more quantitative comparison of the alternative treatment technologies.

NSF International (www.nsf.org) is a not-for-profit organization that certifies drinking water treatment devices by verifying claims from the manufacturers. It has listings of two dozen manufacturers for MtBE removing products.

Conclusion

MtBE is a chemical that may cause health risks and is a great nuisance because of odor and taste problems, although it helps to create less pollution by being added to fuel. This ambiguity is the reason for the lack of clear rules for its control. In the last four years, 19 states have issued a ban for adding MtBE to fuel and probably more will follow. The bans will be a help, but the cleanup process to actually remove MtBE from groundwater and wells has not yet started.

If you have a private well and are concerned about MTBE in your drinking water, look at the checklist (Table 2) and contact your county or regional Department of Health for a list of local laboratories which test water for MTBE. Ensure that the analysis is performed by a laboratory certified to perform EPA certified methods (EPA Method 524.2 should be followed; gas chromatography/mass spectrometry). You should have your water tested annually regardless of whether or not you think your water may be contaminated with any pollutant(s).

Table 2: A checklist for identifying MTBE problems in private wells [18]

	Yes	No	Un-known
Have you tested your well water in the last 12 months?			
If gasoline is sold or stored within 1 mile of your well, have you tested your water specifically for MTBE at least once?			
Have you asked the health department if there is any known groundwater contamination reported in your community?			
If you have an underground fuel storage tank (UST), have you tested the tank for leaks in the last 12 months?			
If you have an above-ground fuel storage tank (AST), have you tested the soil around the tank to determine if there have been leaks, drips, or spills?			
If you have an AST, is it protected with concrete containment and do you closely monitor the tank for leaks, drips, and spills?			
If you have either an AST or UST, do you have procedures to prevent leaks, drips, or spills and as well as methods to clean them up immedi-ately?			
If there has been a vehicle accident or other instances of fuel spills on or near your property, have you tested for MTBE since those occurrences?			
Have you tested your water upon recognizing a change in taste, smell, or appearance?			
If you use gasoline-powered equipment, do you prevent leaks, drips, and spills and do you clean them up immediately?			

If you answer "No" or "Unknown" to any of these questions, you might want to get more information at http://www.epa.gov/mtbe.

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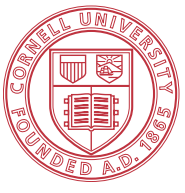

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